Early Childhood Obesity in the United States: An Assessment of Racial/Ethnic Disparities and Risk Factors.

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An Assessment of Racial/Ethnic Disparities and Risk Factors

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Abstract

This dissertation focused on childhood obesity among preschool aged children in the United States, using data from the Early Childhood Longitudinal Study Birth Cohort. Chapter 1 examined racial/ethnic differences in preschool-aged children's weight trajectories and identified sensitive periods at which disparities emerge, using mixed growth models and nonparametric LOESS curves. Racial/ethnic disparities in US children's weight-status and growth trajectories emerge at different ages for different racial groups, but they are generally well established by kindergarten age. Our findings indicate that interventions designed to prevent early childhood overweight/obesity should be implemented early in the life-course.

Chapter 2 assessed the contribution of behavioral and environmental risk factors to racial/ethnic disparities in preschool children's weight status, using decomposition analyses to estimate the percent of disparity explained by individual obesity risk factors. Gaps in the prevalence of socio-economic-status (SES) accounted for a substantial part (ranging from 24.4% to 63.3%) of the explained disparities in BMI z-scores between racial/ethnic minority children and their white peers. Apart from SES and its correlates, infant weight gain during the first 9-months of life, lack of breastfeeding, early introduction of solids, and sugar sweetened beverage consumption were additional factors that played

important roles in explaining racial/ethnic differences. Interventions implemented early in the life-course that target these key contributory risk factors could potentially help reduce the magnitude of racial/ethnic disparities in early childhood obesity

Chapter 3 examined the effect of attending childcare on children's BMI z-scores, employing OLS regression, as well as two quasi-experimental approaches designed to minimize the effect of selection bias and unmeasured confounding. In linear regression models, compared to children in parental care, children in non-parental childcare at 24 months had higher BMI z-scores at kindergarten entry. However, both quasi-experimental approaches revealed no significant effect of childcare attendance on children's BMI z-score, suggesting that the link between non-parental childcare and obesity may not be causal. Previously reported associations may be confounded by unobserved family circumstances resulting in selection into different types of childcare arrangement.

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CHAPTER 1: Racial/Ethnic Disparities in Weight Trajectories of United States Preschool Children

Abstract

Introduction: Although there has been a recent leveling off in US childhood obesity prevalence, racial disparities persist. While previous studies have documented these disparities, less is known about the point at which disparities emerge, how they evolve in early childhood, and the most appropriate early childhood period for targeted interventions.

Objective: To examine racial/ethnic differences in weight trajectories among US preschool-aged children and identify sensitive periods at which disparities emerge.

Methods: Longitudinal study design using data from the Early Childhood Longitudinal Study–Birth Cohort. We employed random effects growth curves to model trajectories of mean BMI z-scores by race/ethnicity and gender. To visualize sensitive periods for emergence of disparities, we used LOESS curves to graph the relationship between age and BMI z-score within each racial group.

Results: Unweighted baseline sample size included ~7200 children. Overall, 54.6% of children were white, 23.1% Hispanic, 15.7% African-American, 3.4% Asian, 2.8% American-Indian, and 0.4% Pacific-Islander. Racial/ethnic disparities in children's weight status were already present at birth, and progressed through kindergarten entry (~5years). Mean BMI z-scores for Hispanic boys and American-Indian boys and girls were already significantly higher by 24-months than their white peers, and remained higher through kindergarten entry. African-American and Asian children started with lower birth-weights compared to whites, but Asian girls' growth trajectory remained slow, while African-American girls experienced steeper increases in BMI z-scores and ultimately overtook their white and Asian peers over time. By kindergarten entry, disparities were present across all racial/ethnic groups.

Conclusion: Racial/ethnic disparities in US children's weight-status and growth trajectories emerge at different ages for different racial groups, but they are generally well established by kindergarten age. Our findings indicate that interventions designed to prevent early childhood overweight/obesity should be implemented early in the life-course.

Introduction

Over the last three decades, the prevalence of obesity among United States (US) children has more than doubled, reaching a peak in 2009-2010 when about 26.7% of children aged 2-5 years were overweight or obese (BMI ≥85th percentile).[1,2] In 2011-2012, there was a reversal to this trend, with obesity prevalence declining to 22.8%.[3] Despite this recent leveling off[1] or decrease,[3] disparities by race/ethnicity persist, and may indeed be worsening.[1,4,5] Over the 30 year period (1971-2002) that increases in childhood obesity rates were occurring nationally, African-American and Mexican-American children experienced much larger secular increases in BMI than their white peers.[6] Indeed, among 10-17 year old children, there was an increase of 211% in racial/ethnic disparities in obesity between 2003 and 2007, as indicated by the relative index of disparity.[7]

Early childhood is a critical period to establish obesity preventive measures, and provides an important window of opportunity to further reverse the childhood obesity epidemic.[8] Most research on childhood obesity has focused on school-aged children. However, data indicate that disparities in obesity prevalence already exist around ages 2-5 years, with rates of obesity being highest among African-American girls and Mexican-American boys.[9] These findings were based on period obesity prevalence estimates, and lacked a longitudinal perspective to pinpoint when disparities emerged and how this evolved over time. Adopting a longitudinal, life-course approach to childhood obesity research could help identify if sensitive periods exist for the emergence of these disparities early in life. Early infancy has been identified as a sensitive period for development of obesity later in childhood,[10-1210-13] and this could be related to risk-factors such as infant feeding practices and rapid infant weight gain. Early life nutritional programming also plays an important contributory role. For example, maternal diet and obesity influence the fetal environment in-utero, and also interact with the postnatal environment to determine a child's body composition.[14,15] As such, offspring of mothers with obesity or diabetes have an increased risk of childhood obesity.[14,15] On the other hand, under-nutrition during pregnancy (as indicated by low birth weight), followed by improved nutrition postnatally, ‘programs’ the fetus so that it is set up to gain weight rapidly after birth – the so-called mismatch hypothesis.[16,17]

Racial/ethnic differences in some of these risk-factors could lead to disproportionate increases in BMI in early childhood. Understanding disparities in body weight throughout both early childhood and school-age is crucial to identifying timely preventive interventions for the broader population as well as targeted to populations most impacted. For example, disparities in infancy and early childhood may point towards the need for preventing racial/ethnic differences in infant feeding practices (e.g. breast-feeding, early introduction of solids) and rapid infant weight gain. By contrast, if disparities in weight only start to emerge in the later preschool years, this may point towards the need to tackle risk factors in early childhood such as TV viewing, home diets or childcare attendance.

This study examines BMI (Body Mass Index) z-score trajectories in a national cohort of preschool-aged children and assesses the age at which disparities originate and expand. Our longitudinal approach enables us to identify sensitive periods for the development or worsening of racial/ethnic disparities in child body weight.

Methods

We used data from the Early Childhood Longitudinal Study Birth Cohort (ECLS-B) study, sponsored by the National Center for Education and Statistics (NCES).[18] ECLS-B is a nationally representative sample of ~10,700 US children born in 2001 and followed over 6-years. The population comprises a diverse sample of children from various socio-economic and racial/ethnic backgrounds. Data on children’s physical, social, and emotional development were collected in multiple settings from children and their parents, teachers, child care and early education providers. Five waves of data were collected: Wave 1 (age: 9-months, 2001-02) Wave 2 (2-years, 2003-04), Wave 3 (preschool, 2005-06), Wave 4 (kindergarten, 2006-07) and Wave 5 (for sample children who entered kindergarten in 2007-2008). A clustered, list frame sampling design was used. American-Indian and Alaska-Native, Chinese, other Asian and Pacific-Islander children, twins, and low birth-weight children were oversampled. Data from waves 1-4 were used for this analysis.

Variables

Dependent variable: BMI z-score: Children's length or height and weight were measured at each wave and used to calculate BMI (weight (kg)/height (m^2)) for children ≥24months. BMI percentile ranking and z-scores, and weight-for-length z-scores (WLZ) at 9-months were calculated using the Centers for Disease Control and Prevention (CDC) sex-specific growth charts.[19] For longitudinal analyses, we used repeated continuous measures of BMI z-scores. We also calculated overweight/obesity prevalence estimates for each wave of data collection, defining obesity as BMI ≥95th percentile, and overweight as BMI ≥85th percentile.[20]

Independent variables

Race/ethnicity: Parents were first asked if their child was of Spanish, Hispanic or Latino origin, and then asked to choose one or more options from various race response categories displayed. Using an ordered stepwise approach described by Anderson et al,[21] we assigned children to one of 6 racial/ethnic categories. Any child who had at least one race/ethnicity group reported by the parent as American-Indian was categorized as American-Indian. In a similar, step-wise manner, we then categorized children to Pacific Islander, African-American, Hispanic, Asian and white categories, in that order. Children's race/ethnicity categorization for analyses was: non-Hispanic-white (reference group), non-Hispanic-black/African-American, Hispanic, Asian, American-Indian and Pacific-Islander.

Socio-economic status (SES): We used an ECLS-B generated composite-variable (categorized as quintiles) for children's SES measured at baseline (Wave 1), which comprised information on the child's household income, the mother and father's educational attainment and occupational status.

Statistical Analysis

We examined weight and height trajectories over time, and excluded children who had implausible values (n=100), who were born with low or very low birth-weight (birth-weight <2500 g) (n=3000), had height and weight values missing for waves (n=150) or extreme BMI values (z-score >3 SD or ≤-3SD) (n=400). Descriptive analyses accounted for the ECLS-B complex sample design and response rates, using appropriate weights.

We started by fitting smooth nonparametric LOESS (locally estimated smoothing splines) function curves[22] to examine the functional form of the relationship between age and BMI z-score, within each racial/ethnic group. LOESS is a locally weighted regression smoother, fitting multiple linear regression lines to small parts of the age axis, and combining central parts of these regression lines, without imposing any assumptions about the functional form. LOESS allows for a visual examination of changes in the association over time, across racial/ethnic groups. We chose values for the smoothing parameter for each fit, based on guidelines provided by Cleveland.[22]

To formally test differences in BMI z-score age-trajectories by race/ethnicity, we used random effects growth curves (unstructured variance-covariance matrix), with children's age-in-months as the time axis. These growth curve models exploit the longitudinal nature of data and allow a subset of the regression parameters for each individual to vary randomly.[23] The mixed model contains both fixed (population) and random (subject-specific) effects. In addition to race, models adjusted for children's SES and age. We incorporated interactions between age and race to examine to what extent age trajectories of BMI z-scores differed by race. If the interactions in the mixed models were significant, we fit exploratory models that included children's birth-weight and 9-month rate of infant weight gain. The rate of weight gain was calculated as the difference in weight at 9-months and birth-weight (in kg), divided by the age in months at the first wave of data collection (~9 months). We used these exploratory models to evaluate to what extent significant differences in BMI z-score trajectories after 24 months is related to birth-weight or infant weight gain. Last, to obtain period estimates, we conducted cross-sectional multivariable analyses of waves 2, 3 and 4 data and examined significant associations between BMI z-scores and race, adjusting for SES.

Given documented differences in BMI by gender,[24] all analyses were stratified by gender. Results from multivariable models also confirmed significant differences by gender. We performed analyses using statistical software (SAS 9.3; SAS Institute, Inc, Cary, NC). This study was approved by NCES and Harvard School of Public Health IRB. Per ECLS-B data reporting requirements, all figures were rounded to the nearest 50.

Results

Descriptive analyses

Table 1.1 summarizes sample characteristics. Unweighted sample size included ~7200 children at baseline. Overall, 53.6% of children were male, 54.6% white, 23.1% Hispanic, 15.7% African-American, 3.4% Asian, 2.8% American-Indian, and 0.4% Pacific-Islander. 46% of parents had less than high-school education, 29.2% had some college/vocational education, and 24.8% were at least college-educated. At baseline (2-years), mean BMI z-scores ranged from 0.19 (SE 0.22) among Pacific-Islander children to 0.67 (0.15) among American-Indian children. Mean BMI z-scores increased with age for all racial groups through kindergarten entry, at which point scores ranged from 0.42 (0.08) among Asian children, and up to 0.98 (0.08) among American-Indian children. Overall, the prevalence of overweight/obesity was 17.1%, 34.4% and 35.1% at each wave of data collection (~24-, 53 and 65 months, respectively). Pacific-Islander children had both the lowest prevalence of obesity at baseline (9.5%) as well as the highest obesity prevalence by kindergarten (51.5%).

Table 1.1: Sample Characteristics, Weighted Means and Frequencies, by Race/Ethnicity

	African-American	Hispanic	Asian	American-Indian	Pacific-Islander	White
Unweighted n[†]	*n~1100*	*n~1300*	*n~1200*	*n~700*	*n~100*	*n~2800*
Overall prevalence (%)	15.7	23.1	3.4	2.8	0.4	54.6
Male	53.6	51.8	53.2	50.4	47.8	50.3
Household Income[≠]						
< $25,000	56.7	51.3	17.7	50.1	26.6	19.8
$25,000 - 50,000	25.7	32.5	25.2	31.6	53.1	29.8
>$50,000	17.7	16.2	57.1	18.3	20.3	50.5
Parent Education[≠]						
≤High School	60.3	68.2	23.9	55.5	72.4	33.2
Some College[§]	30.2	23.0	19.9	36.7	18.1	31.8
≥College	9.5	8.8	56.3	7.8	9.5	35.0
Birth-weight in grams (SE)[‡]	3319.6 (19.7)	3402.5 (15.7)	3301.5 (16.6)	3439.8 (40.6)	3384.2 (67.5)	3469.3 (15.4)
BMI Z-score (SE)						
2-yr (2003-04)	0.44 (0.12)	0.55 (0.09)	0.29 (0.09)	0.67 (0.15)	0.19 (0.22)	0.37 (0.07)
Preschool (2005–06)[≠]	0.67 (0.07)	0.83 (0.05)	0.41 (0.07)	1.02 (0.09)	0.72 (0.24)	0.59 (0.03)
Kindergarten (2006)[≠]	0.75 (0.05)	0.86 (0.05)	0.42 (0.08)	0.98 (0.08)	0.91 (0.21)	0.59 (0.02)
Overweight/Obesity Prevalence (%)						
2-yr (2003-04)	16.9	18.7	13.0	24.7	9.5	16.4
Preschool (2005–06)[≠]	37.0	41.2	26.5	47.0	47.8	30.3
Kindergarten (2006)[≠]	40.5	41.9	29.5	46.0	51.5	30.3

[†] Unweighted sample size rounded to the nearest 50, in compliance with NCES ECLS-B data reporting requirements.
[§] Includes Vocational School
[≠] p value for difference <0.05

LOESS curve analyses

Figure 1.1 displays LOESS curves of BMI z-scores by age for each racial/ethnic group from a model that adjusts for SES and includes interactions between age and race. BMI z-scores for Asian girls start and trend below scores for girls of all other racial groups throughout the study-period. BMI z-scores for African-American girls also start lower than scores for white girls, but by about age 36-months lines cross so that BMI z-scores are higher for African-American girls. Notably, by age 50-months the widening in differences between trajectories for African-American and white female sharpens; although the slope for African-American girls becomes less steep, z-scores for white girls start to decline. Throughout the study period, BMI z-scores for Hispanic, American-Indian and Pacific-Islander girls are higher than those for white, African-American and Asian girls. Of note, the slopes for African-American and Pacific-Islander girls appear to be steepest compared to girls from other racial groups.

Similar to girls, Asian boys had the lowest BMI z-score (followed closely by white boys) throughout the study period (Figure 1.2). BMI z-scores for Pacific-Islander boys were the same as those for white and Asian boys at month 24, but they increased dramatically and then crossed the Hispanic, African-American (at ~45-months), and American-Indian lines (at ~58-months), and only started to decrease at about 65-months. Hispanic and African-American boys had higher BMI z-scores than white boys already by age 24-months, and these disparities remained relatively unchanged throughout all ages.

Figure 1.1: Association of Age and Race with BMI Z-score for Girls, aged 24 to 74.5 months in the United States, using LOESS Curves

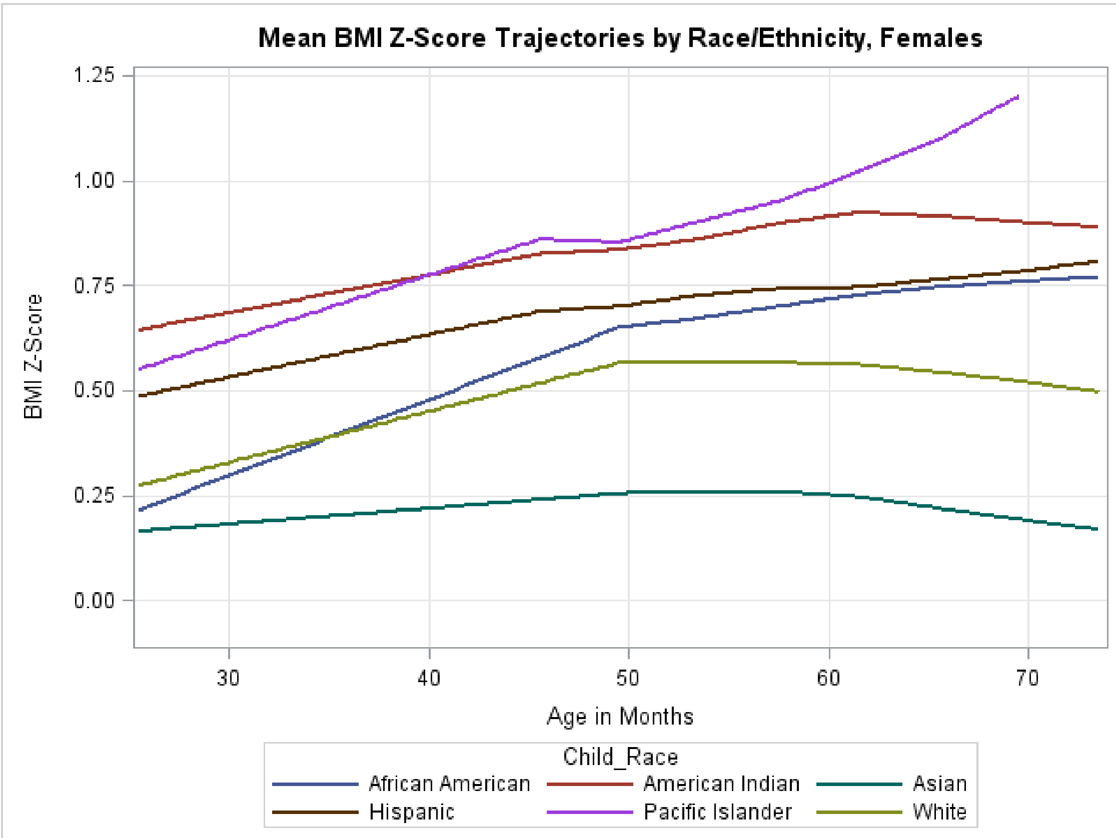
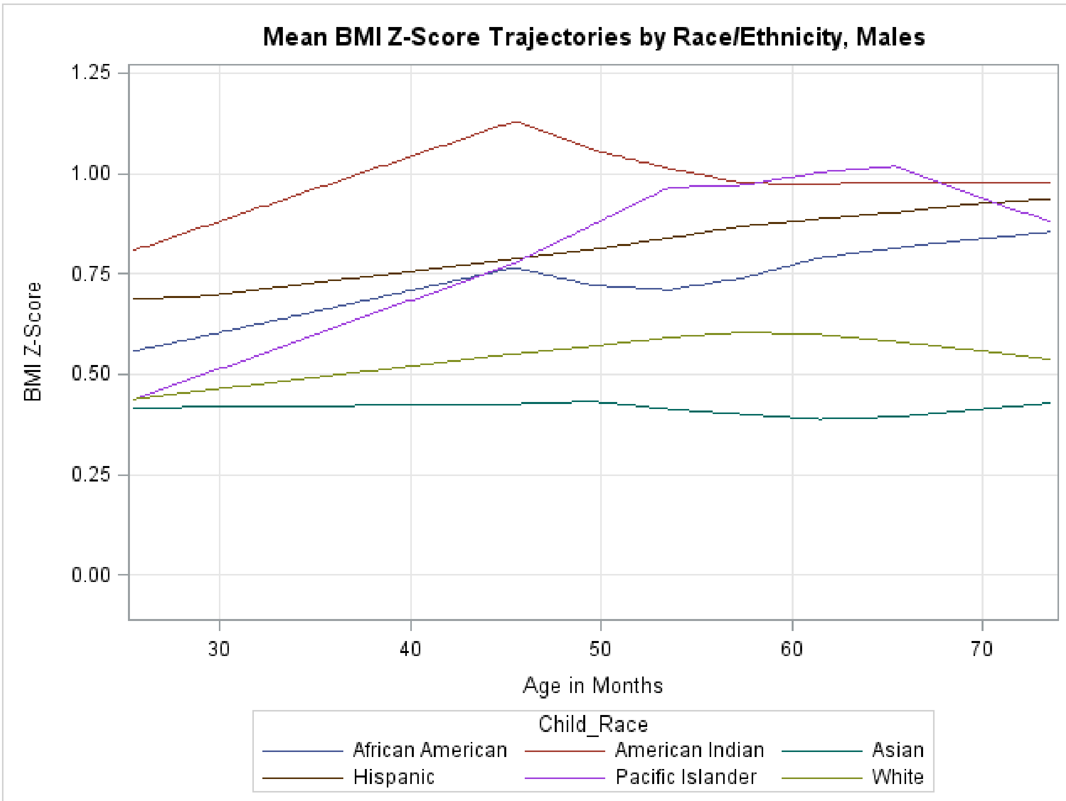


Figure 1.2: Association of Age and Race with BMI Z-score for Boys, aged 24 to 74.5 months in the United States, using LOESS Curves



Growth-curve models

Table 1.2 shows results from sex-stratified growth curve models, with age centered at 24-months, and whites as reference category. At this initial age, Hispanic and American-Indian boys already had higher BMI z-scores than white boys. Among girls, only American-Indians had significantly higher scores than white girls. The last rows of the table show estimates from interactions between age and race. Among boys, there were no significant differences in age trajectories between white boys and those from other racial groups, suggesting that disparities were already present by 24-months and remained unchanged up to kindergarten entry. By contrast, among girls there was a significant difference in BMI z-score slopes across races, as indicated by a significant interaction term for the overall model (*p*=0.02). Specifically, there was a steeper increase in BMI z-score by age among African-Americans (*β* for interaction=.005 (0.002), *p*=0.02), and a significantly less steep slope for Asian girls (*β* for interaction: -.004 (0.002), *p*=0.04).

Table 1.2: Random Effects Growth Model of Unadjusted and Adjusted Mean Difference in BMI-Z Score and BMI-Z Score Change by Race/Ethnicity and Gender

	Male		***Female***	
	Model 1 β (SE)	***Model 2*** β (SE)	***Model 1*** β (SE)	***Model 2*** β (SE)
Intercept	.43 (.04)	.55 (.06)	.34 (.04)	.53 (.06)
Race/Ethnicity†				
African-American	.09 (.08)	.05 (.08)	-.04 (.08)	-.10 (.08)
Hispanic	.24 (.07)**	.20 (.08)**	.15 (.08)**	.09 (.08)
Asian	-.04 (.09)	-.02 (.08)	-.16 (.08)	-.13 (.08)
American-Indian	.43 (.09)**	.39 (.09)**	.32 (.09)**	.26 (.09)**
Pacific-Islander	.05 (.20)	.02 (.20)	.19 (.22)	.14 (.22)
Age§	.004 (.001)**	.004 (.001)**	.007 (.001)**	.007 (.001)**
Socioeconomic status		-0.03 (.01)**		-.06 (.01)**
African-American*Age	.003 (.002)	.003 (.002)	.005 (.002)**	.005 (.002)**
Hispanic*Age	.001 (.002)	.001 (.002)	.000 (.002)	.000 (.002)
Asian*Age	-.004 (.002)	-.004 (.002)	-.004 (.002)**	-.004 (.002)**
American-Indian*Age	.001 (.002)	.001 (.002)	.000 (.002)	.000 (.002)
Pacific-Islander*Age	.008 (.006)	.008 (.006)	.005 (.006)	.005 (.006)

†*Reference group =non-Hispanic white*
**p-value <.05
§Age is centered at 24-months

Table 1.3 shows estimates of disparities at each age point. At 24-months, mean BMI z-scores for Hispanic and American-Indian boys were significantly higher ((0.26 (0.08) p=0.002) and (0.34 (0.10) *p*=0.001) respectively) than their white peers. By the preschool year, mean scores were still significantly higher among Hispanic and American-Indian boys, and now also significantly lower among Asian boys, compared to white boys. These findings persisted at kindergarten entry, at which time BMI z-scores were significantly different (compared to white boys) across all racial groups, except Pacific-Islander boys. Among girls, significant differences in mean BMI z-scores were only present between American-Indian and white girls at baseline (β =.41 (0.11), p=0.0002). At preschool age, girls' BMI z-scores were significantly higher for Hispanic (0.14 (0.06), p=0.02) and American-Indian girls (β=0.24 (0.07), p=0.0004), while scores for Asian girls were significantly lower (β= -0.26 (0.06), p<0.0001) compared to their white peers. By kindergarten age, Asian girls continued to have lower BMI z-scores than white girls, while disparities in BMI z-scores relative to white girls were largest for Pacific-Islander girls, followed by American-Indian, African-American and Hispanic girls.

An important question is how observed disparities in BMI z-scores starting at 24 months relate to weight differences at birth and 9 months. To explore this issue, Table 1.5 in the appendix shows the birth-weight and weight-for-length Z-scores (WLZ) across racial/ethnic groups, by gender -adjusting for SES. Among girls, African-Americans, Hispanics and Asians had significantly lower birth-weights compared to white girls. At 9 months, Hispanic, American-Indian and Pacific-Islander girls' WLZ-scores were significantly higher than those of white girls, while Asian girls' WLZ-scores were significantly lower. There was no difference between African-American and white girls' WLZ-scores at 9-months. Among boys, African-Americans and Asians had significantly lower birth-weights compared to white boys, while Pacific-Islander and American-Indian boys' birth-weights were higher. At 9 months, Asian boys' WLZ-scores were lower than those of white boys, while American-Indian and Pacific Islander boys had significantly higher WLZ-scores. In sensitivity analyses we incorporated these weight measures at birth and infant weight gain in the models to examine to what extent differences in BMI z-score trajectories after 24 months were related to birth-weight or infant weight gain. Incorporating these measures of early life weight trajectories however, did not impact differential trends in BMI z-score trajectories at 24 months and beyond.

Table 1.3: OLS Models of Cross-sectional Associations between BMI-z score and Race/Ethnicity, by Wave of Data Collection and Gender

	Male			***Female***		
	2-yr (2003-04)	**Preschool (2005–06)**	**Kindergarten (2006)**	**2-yr (2003-04)**	**Preschool (2005–06)**	**Kindergarten (2006)**
	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
Intercept	.84 (.55)	.17 (.27)	.45 (.36)	-.25 (.65)	.90 (.25)	1.37 (.35)
Race/Ethnicity						
African-American	.14 (.09)	.11 (.06)	.18 (.07)*	-.07 (.10)	.08 (.06)	.13 (.06)*
Hispanic	.26 (.08)*	.19 (.06)*	.26 (.07)*	.09 (.09)	.14 (.06)*	.12 (.06)*
Asian	-.03 (.08)	-.15	-.16 (.06)*	-.10 (.09)	-.26 (.06)*	-.24 (.06)*
American-Indian	.34 (.10)*	.42 (.07)*	.38 (.07)*	.41 (.11)*	.24 (.07)*	.30 (.07)*
Pacific-Islander	-.12 (.21)	.32 (.17)	.21 (.18)	.21 (.24)	.25 (.17)	.44 (.19)*
Age	-.02 (.02)	0.01	0.01 (.01)	.03 (.03)	0.00 (.00)	-.01 (.01)
Socioeconomic status	.00 (.02)	-0.04	-0.05 (.02)*	-.04 (.02)	-0.05 (.02)*	-.06 (.02)*

*p-value <.05

Discussion

Our study examined differences in weight status and age trajectories in BMI z-scores by race/ethnicity in early childhood, using data from a national cohort of US preschool-aged children. We found that racial/ethnic disparities in children's weight status were already present at 24months, and progressed through kindergarten entry. American-Indian children had significantly higher birth-weights than their white peers, and this disparity persisted through infancy until kindergarten entry, even though their growth trajectories were not significantly faster than those of white children. This could indicate that American-Indian's relatively higher birth-weights may set them up for a much higher weight trajectory than their peers over time. As such, interventions targeting this population would need to begin in the preconception or prenatal periods. By kindergarten entry, rates of obesity overall were highest among Pacific-Islander girls.

By contrast, African-American, Hispanic and Asian children had lower birth-weights than their white peers, but by 9-months different growth patterns began to emerge across groups. The contrasting experience of African-American and Asian girls was particularly striking. Under the mismatch of pre- and postnatal growth trajectories hypothesis, we would have expected the lower birth-weight status experienced by both groups to have set them up for rapid weight gain and subsequent obesity after birth. However, we found that although both groups started with significantly lower birth-weights compared to their white peers, Asian girls grew at a slower pace, such that their WLZ- and BMI Z-scores remained lowest through kindergarten entry, while African-American girls grew faster and eventually overtook their white and Asian peers. Models adjusting for birth-weight and infant weight gain did not impact differential trends in BMI z-scores at 24 months and beyond, however, suggesting that differences in BMI Z-score trajectories are not explained by weight differences that existed before 9 months. These findings may highlight the relative importance of the postnatal environment compared to the prenatal environment for these groups.

The Hispanic Paradox

Although Hispanic children started with relatively lower birth-weights, they underwent a period of rapid growth early in life, such that after age 2 years, their growth patterns largely mirrored those of American-Indian children, the fastest growing group. By kindergarten entry, the overall prevalence of overweight/obesity among Hispanic boys and girls was 41.9%. These findings are consistent with a previously documented study describing the favorable to unfavorable transition in early life-course health from birth to early childhood among US Latino children.[25] This study showed that Mexican-American children had relatively healthy weight distributions at birth, but a few years later developed higher rates of childhood obesity. Another study that evaluated preschool children sampled from 20 large US cities found that Latino preschoolers were twice as likely to be obese as their white or African-

American peers, and these differences were not explained by maternal education, household income or food insecurity.[26] These recent findings have led some researchers to suggest that the epidemiologic paradox that exists at birth among Latino children may no longer apply by their preschool years.[27]

Contrasts between African-American Boys and Girls

BMI z-scores among African-American girls were lower than those for white girls at 24-months, but they increased faster, resulting in the emergence of black/white disparities at about 36-months, with a subsequent progressive widening of differences from 50-months of age. Factors contributing to this sensitive period of steep growth curves are not clear, but could be environmental in origin, for example related to childcare attendance. Studies suggest that children who receive non-parental childcare could be at increased risk of childhood obesity,[28-30] and African-American children are more likely to receive non-parental childcare.[29,31] If this association were to be causal, the differential exposure of African-American girls to non-parental child care, compared to their white peers could influence their rate of growth in preschool years. African-American boys on the other hand had BMI Z-score trajectories that were already higher than those of their white peers by 24 months, and continued to gain weight at a similar rate through kindergarten entry. This would suggest that the period of rapid growth among African-American boys occurred before age 24 months, while for their female counterparts it occurred after 24 months. Reasons for gender-based differential trajectory patterns observed between African-American boys and girls are not known, but could be as a result of biology-based sex differences. Sex differences in BMI peak in infancy have been previously documented in the literature,[32,33] and higher peak BMI in infancy is known to be correlated with higher BMI z-scores at 4 years.[33] However, a recent study has also shown that these findings vary by race: African-American boys attain BMI peak earlier, and have higher BMI peak values than their female counterparts.[33] Similar sex differences in BMI peak were not found among white children. This could suggest that beyond biology, additional explanatory factors should be considered, such as: differences in how African-American boys and girls are socialized, differences in early life factors, e.g. breast feeding rates or duration, as well as unconscious (or conscious) gender biases that could influence how boys and girls are raised or nourished. A study on obesity and acculturation described gender differences in weight and weight gain among young, school-aged children in immigrant families.[34] Boys in families with parents who were more recent immigrants weighed more and grew significantly faster than their female counterparts. Reasons for these findings were not clear, but authors posited a "place of socialization hypothesis" as a possible contributory factor: i.e. immigrant parents who were socialized in foreign countries indulge their male children as a result of gender-based beliefs. Consequently, their parenting practices placed the male children at greater risk of obesity.[34]

We believe our study provides a comprehensive picture on disparities by providing better insight into early childhood weight trajectories among traditionally understudied racial/ethnic minority groups. However, some limitations should be considered. BMI is an imperfect measure of adiposity in children, especially given variations in body fat by age, gender and race/ethnicity.[35,36] In order to optimize sample sizes of minority children, we used a race prioritization procedure, which could have introduced misclassification bias. We conducted sensitivity analyses using the ECLS-B generated race categories, and results remained unchanged. However, with the race prioritization approach, essentially no child was categorized as mixed race. We documented prevalence rates of overweight/obesity among Pacific-Islanders that were staggeringly high – up to 51.5% at kindergarten entry. These figures are consistent with previously reported rates of 58% among Pacific-Islander children aged 2-10 years attending a Hawai'i Health Maintenance Organization.[37] Due to the small sample sizes, our results for Pacific-Islander children should be interpreted with caution. However, we thought it was important to include this population in this study, because very little information on early childhood obesity is available on Pacific-Islanders in the literature. In spite of these limitations, this study makes an important contribution to the obesity research field. The reliance upon ECLS-B data to address study questions helped generate results that provided a fuller, longitudinal perspective of weight status and growth trajectories in early childhood, and also highlighted how racial/ethnic differences in children's weight status developed and evolved over time.

Conclusion

Our findings indicate that interventions designed to prevent early childhood overweight/obesity should be implemented early in the life-course, in some cases before 24 months. Many current interventions, such as those targeting children in preschool and kindergarten start after 24 months and may thus be unable to prevent the emergence or curb disparities in BMI z-scores that start well before this age. Public health programs may be required in the preconception/prenatal period for some groups, and as early as between birth and 9-months for others. More research is required to elucidate specific risk-factors and mechanisms that underlie racial differences in growth-trajectories. Our findings suggest that policies and interventions may need to tailor different risk-factors that could be unique to each racial/ethnic group.

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CHAPTER 2: Explaining Racial/Ethnic Disparities in Early Childhood Obesity

Abstract

Background: Childhood obesity is a significant problem among US children, particularly among those from certain racial/ethnic minority groups. Several risk factors are also more prevalent in these populations, but it is unclear to what extent these differences contribute to racial/ethnic disparities in children's weight status.

Objectives: To assess the contribution of social and behavioral risk factors to racial/ethnic disparities in children's weight status in early childhood.

Methods: We used nationally representative data of ~10,700 children in the Early Childhood Longitudinal Study Birth Cohort followed from age 9 months through kindergarten entry. We assessed the explanatory power of 3 groups of risk factors: (a) maternal: e.g. maternal smoking during pregnancy; (b) infancy: e.g. breast-feeding; and (c) early childhood: e.g. physical inactivity. We estimated the percent of disparity explained by individual obesity risk factors, employing Oaxaca-Blinder decomposition analyses.

Results: African-American children had the least favorable obesity risk factor profiles while Asian children had the most favorable risk profile. Gaps in the prevalence of socio-economic-status (SES) accounted for a substantial part (ranging from 24.4% to 63.3%) of the explained disparities in BMI z-scores between racial/ethnic minority children and their white peers. Racial differences in socioeconomic status measures was the largest contributor to racial differences in BMI, followed by infant weight gain during the first 9-months of life, breastfeeding practices, early introduction of solids, sugar sweetened beverage consumption, and maternal weight. Other childhood risk factors, (e.g. fruit and vegetable consumption), played little role in explaining racial/ethnic differences in children's BMI z-scores.

Conclusions: We decomposed racial/ethnic disparities in preschool children's weight status into contributing factors. Disparities are to a large extent explained by differences in family socioeconomic status, followed by rapid infant weight gain, sugar sweetened beverage consumption and lack of breastfeeding. Interventions implemented in early life that target these risk factors could help curb widening racial/ethnic disparities in early childhood obesity.

Introduction

The prevalence of childhood obesity is significantly higher among racial/ethnic minority children in the United States (US).[1] In particular, American-Indian, African-American and Hispanic children bear a disproportionate burden of overweight and obesity[2-4], placing them at increased risk of the myriad associated consequences of the disease.[5,6] Obesity is a complex condition that has been linked to multiple genetic, epigenetic, biological, social and environmental determinants and risk factors.[7-9] Some of these risk factors vary by race/ethnicity and socio-economic status,[10-15] leading some researchers to hypothesize that differences in the prevalence of these factors across racial groups could explain observed disparities. It remains unclear if and to what extent these differences contribute to racial/ethnic disparities in children's weight status and growth trajectory.

To date, only a few studies have evaluated the role that social and behavioral factors play in explaining racial/ethnic differences in early childhood obesity rates.[14,16,17] These studies found that various prenatal, perinatal and early life risk factors (e.g. maternal smoking during pregnancy, breastfeeding, child-care arrangements, sleep duration, television viewing, fast food intake, family meals) could largely explain BMI differences across racial groups. However, some gaps in knowledge remain. In these previous studies, obesity risk factors were categorized and modeled as a group; it remains unclear if one or more of these risk factors may drive or explain the disparities. In addition, there may be sensitive periods when racial/ethnic disparities in early childhood obesity emerge, and this may differ significantly by gender. (Chapter 1) For example, African-American girls have lower birth-weight than their white peers, but grow at a more rapid pace than white girls, resulting in the emergence of black/white disparities by month 36. This suggests that African-American and white girls may be exposed to different behavioral (e.g. lack of breastfeeding) or environmental (e.g. daycare) risk factors in the first years of life, as well as different practices related to feeding, physical activity and child rearing.[18,19] Further, most of the previously published papers did not use US national data; the one study that did focused only on black and white children.[14,16,17] Our study relied on national data that included children of multiple racial/ethnic groups, and also examined the contribution of a wide set of individual risk factors as potential sources of obesity disparities. Results could therefore provide a fuller picture of the race/obesity relationship, contributing to generalizability of the findings, and also shed light on specific modifiable risk factors that could be targeted in interventions.

The goal of this study was to assess the contribution of social, behavioral and environmental risk factors to racial/ethnic disparities in children's weight status in early childhood. We applied decomposition analysis techniques commonly used to examine wage differentials,[20,21] and health disparities[22,23] to examine and quantify the degree to which different known obesity risk factors explain racial/ethnic disparities in children's weight status.

Methods

We used data from the Early Childhood Longitudinal Study, Birth-Cohort (ECLS-B), a stratified clustered survey designed and administered by the US Department of Education National Center for Education and Statistics (NCES).[24] Data were collected on ~10,700 US children born in 2001 and followed for 6 years. Sampling methodology was a clustered list frame of US registered births in the National Center for Health Statistics vital statistics system. American-Indian and Alaska Native children, Chinese, other Asian and Pacific-Islander children, twins, and low birth weight children were oversampled. Waves of data were collected when the children were approximately 9 months (Wave 1), 2 years (Wave 2), 4 years (Wave 3/preschool interview) and between 5-6 years old (Wave 4/Kindergarten entry interview). Response rate for wave 1 was 74.1%. We used data from waves 1-4 for this analysis. This study was approved by the NCES and the Harvard Chan School of Public Health IRB. Per NCES ECLS-B data reporting requirements, all figures were rounded to the nearest 50.

Variables and their Measurement

Outcome variable: BMI z-score: We used BMI z-scores from Wave 4 (Kindergarten entry) as our main dependent variable. We calculated BMI percentile ranking and z-scores using the Centers for Disease Control and Prevention (CDC) sex-specific BMI-for-age growth charts.[25]

Exposure variables

Race/ethnicity: Parents reported their child's race/ethnicity by choosing one or more options from various race response categories displayed on a card. Based on parent responses, children were assigned to the following racial/ethnic categories: Asian, Pacific-Islander, American-Indian, non-Hispanic white, non-Hispanic-black, Hispanic and mixed race. We assigned children to one of 6 racial/ethnic categories: any child who had at least one race/ethnicity group reported by the parent as American-Indian was categorized as American-Indian. In a similar, step-wise manner, we then categorized children to Pacific Islander, African-American, Hispanic, Asian and white categories, in that order. Due to sample sizes and distributions, we restricted our analytic sample to the following categories: non-Hispanic white (reference group), African-American, American-Indian, Hispanic and Asian.

Obesity Risk Factors

The following variables were collected at Wave 1 or Wave 3 of data collection, and we categorized them into three groups: a) Maternal risk factors, measured at the 9 month interview (wave 1); b) Infancy risk factors, measured at the 9 month interview (wave 1); and c) Early childhood risk factors, measured at the preschool interview (wave 3). We chose variables from the wave 1 and preschool interview (wave 3) to ensure that the risk factor measurement preceded the outcome – BMI z-score at kindergarten entry (wave 4). Table 2.4 in the Appendix displays all variables, their measurement and how they were categorized.

Maternal risk factors: These included: a) mother's weight in kg; and b) maternal history of smoking during pregnancy (yes/no).

*Infancy risk factors: T*hese included the following variables: *a)* History of Breast-feeding (ever breastfed, vs. not); b) Age at introduction of solids: we dichotomized this variable based on whether solids were introduced before age 4months. c) Infant weight gain – this was based on the 9-month rate of infant weight gain, calculated as the difference in weight at 9-months and birth-weight (in kg), divided by the age in months at the first wave of data collection (~9 months).

Early childhood risk factors: These included the following variables: a) Television viewing (if child watched ≥2 hours/day of TV/DVD on weekdays or weekends); b) Sugar Sweetened Beverage Consumption: Using methods described by DeBoer et al[26], we categorized children as regular sugar sweetened beverage (SSB) drinkers vs. infrequent/nondrinkers. Regular SSB drinkers were identified as children whose parents reported that they drank ≥1 serving of SSB/day; c) Fruit and Vegetable consumption: We combined responses to questions on fruit and vegetable consumption over the past 7 days, and dichotomized this variable as adequate fruit and vegetable consumption (1 time/day, 2 times/day, 3 times/day, 4 or more times/day) vs. inadequate fruit and vegetable (for responses: 1-3 times during the past 7 days, 4-6 times during the past 7 days, and child did not eat fruit/vegetables during the past 7 days) consumption.; d) Physical activity: We dichotomized this variables based on parent responses to a question on how often the child went outside to walk or play (at least once a day vs. <once/day); e) Family meals: we categorized children as having regular family meals if the family ate at least 4 meals together/week; f) Childcare arrangement: The ECLS-B provides a composite variable created to indicate the primary, non-parental childcare arrangement, based on where the child spent the most hours per week. We dichotomized this variable as parental vs. non-parental childcare.

Other covariates: We identified additional variables and confounders of the race/BMI z-score or risk factor/BMI z-score relationships. These included 1) child age; 2) household socio-economic status, which was a composite variable developed by ECLS-B for children's socio-economic status (SES) at baseline data collection (wave 1). The variable was categorized as quintiles, and comprised information on the mother and father's educational attainment, occupational category and prestige score, and household income; 3) household food insecurity, which was assessed using a series of questions obtained from the Household Food Security Scale.[27] If parents had three or more affirmative responses to questions, the household was categorized as food-insecure (vs. food secure). 4) Finally, we included a variable for self-reports of unsafe neighborhood safety.

Statistical Analysis

We created our overall study sample by examining children's weight and height trajectories at each wave, excluding children who had implausible values (n=100), who were born with low or very low birth-weight (birth-weight <2500 g) (n=3000), had height and weight values missing for waves (n=150) or extreme BMI values (z-score >3 SD or ≤-3SD) (n=400). Using ECLS-B sample weights, we examined differences in the distribution of all variables by race/ethnicity (two-sided p<0.05). Given documented differences in BMI by gender,[28] all analyses were stratified by gender.

To estimate the percent of disparity explained by known obesity risk factors, we employed decomposition analytic techniques.[22,23] The use of a traditional causal inference framework can be challenging in situations where the exposure of interest – race, is non-manipulable.[29] It has been recommended that race coefficients in models that adjust for confounders and obesity risk factors can be interpreted as the racial inequality that would remain if the distribution of socioeconomic status or obesity risk factors were equalized across racial groups.[29] The main advantages of the decomposition approach are: (i) unlike the models that use a dummy or class variable for race/ethnicity, this method provides individualized estimates of disparity after accounting for other covariates in the model; (ii) partitions observed disparities into two parts: “explained disparity” (the component explained by group differences in model covariates), and “unexplained disparity” (the remaining unexplained component).

The decomposition approach was applied to pairwise comparisons of white and racial minority children, taking the former as reference. Here, we describe the steps employed for the decomposition approach – based on OLS models, using the analyses comparing white and African-American boys in our study sample as an example. First, a multivariable OLS regression model is fit to predict BMI z-scores among white boys. Another OLS model for African-American boys is fit, using the beta-coefficients for each of the covariates in the white boys’ model. This model predicts what BMI z-scores would be for African-American boys, had they the same risk factor distribution as white boys. These two regression models provide the observed (O_{AA}) and expected (E_{AA}) values for African-American boys, as well as the observed values for white boys (O_W). Next, the average differences between expected and observed values for African-American boys are computed, (which gives the “unexplained disparity” ($D_{1AA} = O_{AA} - E_{AA}$)), the “explained disparity” ($D_{2AA} = 0_W - E_{AA}$), and the observed disparity ($D_{WAA} = O_W - O_{AA}$). Finally, these values are used to calculate the Percent Explained (PE%) - our main estimate of interest, given by (D_{2AA}/D_{WAA}) * 100. It indicates how much of the mean difference in BMI z-scores is accounted for by group differences in the distributions of the model covariates. We performed sex-stratified pairwise comparisons between white children and each racial/ethnic minority group. For the decomposition analyses, we excluded observations that had missing values on any of the independent variables, leaving us with a sample size of ~4400. We did this to ensure equivalent samples across all models. All analyses were conducted using statistical software (SAS version 9.3; SAS Institute, Inc, Cary, NC and STATA 12).

Results

Overall, 51.3% of the sample was male, 54.6% white, 23.3% Hispanic, 15.8% African-American, 2.9% American-Indian and 3.5% Asian.(Table 2.1) Hispanic, African-American and American-Indian children were more disadvantaged socio-economically, compared to their Asian and white peers. For example, a larger proportion of African-American (56.7%), Hispanic (51.3%) and American-Indian (50.1%) children belonged to households earning less than $25,000/year compared to white (19.8%) and Asian children (17.7%). In terms of distribution of obesity risk factors by race, African-American children were seemingly at highest risk, and Asians at lowest risk, based on risk factor prevalence. A larger percentage of Asian children were breastfed, started solid foods later in life, watched ≤2 hours of TV, consumed less sugar sweetened beverages, and ate more fruits and vegetables, compared to their peers of other racial/ethnic groups. Asian mothers also had lower average weight, as well as the lowest prevalence of maternal smoking during pregnancy. The obesity risk profile among Hispanic, African-American and American-Indian children was less favorable, compared to white and Asian children, with African-American children having the highest prevalence of risk factors of all racial/ethnic groups. Because the lower prevalence of obesity risk factors among Asian and white children could reflect, at least in part, their more advantaged status socioeconomically, compared to their racial minority peers, we also estimated the adjusted prevalence of risk factors. After controlling for SES, neighborhood safety and food insecurity, African-American children still had the highest prevalence of obesity risk factors, while prevalence rates among Hispanic children became more similar to those of Asian children. At wave 2 (~2 years), Asian children had the lowest BMI z-scores (0.29 (0.08SD)), while American-Indian children had the highest BMI z-scores (0.67 (0.15SD)) of all racial/ethnic groups. At kindergarten entry, BMI z-scores were also lowest among Asian children (0.41 (0.07)) and highest among American-Indian children (0.98 (0.08)), compared to other racial/ethnic groups.

Table 2.1: Child and Parent Socio-demographic Characteristics, and Obesity Risk Factors by Child Race/Ethnicity

	Overall	*African-American*	*Hispanic*	*Asian*	*American-Indian*	*White*
Overall prevalence (%)		15.8	23.3	3.5	2.9	54.6
Male (%)	51.3	53.6	51.8	53.2	50.4	50.3
Household Income (%)**						
< $25,000	33.5	56.7	51.3	17.7	50.1	19.8
$25,000 - 50,000	29.7	25.7	32.5	25.2	31.6	29.8
>$50,000	36.8	17.7	16.2	57.1	18.3	50.5
Parent Education (%)**						
≤High School	45.8	60.3	68.2	23.9	55.5	33.2
Some College[#]	29.2	30.2	23	19.9	36.7	31.8
≥College	25.0	9.5	8.8	56.3	7.8	35.0
Food insecurity (%)	11.8	16.9	17.7	6.5	15.1	8.1
Neighborhood Safety (%)	8.0	15.6	12.5	3.4	9.2	4.2
BMI Z-score (SE)						
2-yr (2003-04)	0.42 (0.04)	0.44 (0.08)	0.55 (0.08)	0.29 (0.08)	0.67 (0.15)	0.37 (0.05)
Preschool (2005–06)**	0.67 (0.02)	0.67 (0.05)	0.82 (0.05)	0.41 (0.07)	1.02 (0.09)	0.59 (0.03)
Kindergarten (2006)**	0.68 (0.02)	0.75 (0.04)	0.86 (0.04)	0.41 (0.07)	0.98 (0.08)	0.59 (0.03)
Maternal Risk Factors						
Maternal Weight, kg (SE)**	72.2 (0.44)	78.76 (1.15)	71.10 (0.85)	60.46 (0.63)	76.02 (2.2)	71.30 (0.55)
Maternal Smoking during pregnancy (%)**	9.1	6.7	4.4	0.7	19.4	13.0
Infancy Risk Factors (%)						
Never breastfed**	29.2	46.6	23.8	16.3	28.4	27.3
Early introduction of solids**	23.7	29.8	21.2	7.5	28.6	23.9
Infant weight gain[‡**]	0.57 (0.01)	0.61 (0.01)	0.59 (0.01)	0.56 (0.01)	0.64 (0.02)	0.57 (0.01)
Early Childhood Risk Factors (%)*						
TV viewing >2 hours/day**	35.6	50.6	44.8	29.4	41.6	27.5
Physical inactivity**	56.1	60.4	56.8	67.8	50.8	54.1
Sugar sweetened beverage consumption**	30.1	41.4	35.7	21.7	33.5	25.0
Fruit and Vegetable consumption <1/day	18.5	20.3	16.8	16.5	19.8	19.0
Family meals <4/week**	16.1	24.6	20.2	16.9	16.8	11.9
Non-parental childcare**	80.2	84.0	73.2	84.8	79.3	82.0

‡9-month rate of infant weight gain, calculated as the difference in weight at 9-months and birth-weight (in kg), divided by the age in months at the first wave of data collection (~9 months)
*Measured at wave 3 of data collection
**p value for the difference <0.05

Results for the decomposition analysis comparing predicted average BMI z-score between white vs. African-American, white vs. Hispanic, white vs. Asian and white vs. American-Indian boys and girls are displayed in Tables 2.2 and 2.3. The first row displays the overall percent explained (PE%) for each pairwise comparison. 94.5% of the observed disparities in BMI z-scores between white and African-American girls was explained by differences in the distributions of obesity risk factors included in the model. By contrast, the overall PE% for white vs. Asian girls was 14.9%, indicating that obesity risk factors included in the model did not explain much of the observed disparities for this group. Subsequent rows of Tables 2.2 and 2.3 display coefficients for individual covariates, as well as the total coefficient of the explained part of the model. For white vs. African-American boys the total coefficient for the explained part was (β= -0.134 (0.05) p=0.01). The proportion of the total explained disparity that is attributable to each risk factor is also displayed. For example, as seen in the 3rd column, differences in SES accounted for about 36% of the explained disparity between African-American and white boys. Indeed, for all racial/ethnic minority boys, a significant proportion (ranging from 24% to 57.4%) of the total explained disparity was attributable to SES measures. The same was true for girls, where gaps in SES or SES indicators (neighborhood safety and food insecurity), accounted for >30% of the explained disparities. Other than SES, infant weight gain was another factor that played a major role in explaining disparities between white children and all racial/ethnic minority boys and girls. For example, differences in the rate of infant weight gain accounted for 47% of the explained gaps between white and Hispanic girls. Consumption of sugar sweetened beverages was another important contributory factor, primarily among racial/ethnic minority boys, while breastfeeding history was important among African-American girls. Among Asian boys and girls, maternal weight, breastfeeding and timing of solids introduction were risk factors that contributed moderate amounts to the overall explained gap. Other variables like fruit and vegetable consumption and TV viewing at 3years contributed little or nothing in explaining children's racial/ethnic differences in BMI z-scores at kindergarten entry. Of note, only coefficients for infant weight gain among African-American, Hispanic and American-Indian girls, and African-American boys were significant at the $p<0.05$ level.

Table 2.2: Oaxaca-Blinder decomposition of BMI Z-Scores difference, Males

	White vs. African-American		White vs. Hispanic		White vs. Asian		White vs. American-Indian	
	Explained		Explained		Explained		Explained	
	β (SE)	%	β (SE)	%	β (SE)	%	β (SE)	%
Overall PE (%)[±]		52.3		24.7		46.8		32.3
Age	0.002 (0.00)	-1.5	-0.010 (0.01)	10.6	-0.001 (0.00)	-0.9	-0.031 (0.02)*	26.6
Socio-economic Status	-0.049 (0.01)	36.2	-0.053 (0.04)	57.4	0.023 (0.02)	24.4	-0.050 (0.04)	42.8
Food Insecurity	0.003 (0.01)	-2.6	0.005 (0.02)	-5.3	0.000 (0.00)	-0.4	0.003 (0.01)	-2.3
Neighborhood safety	-0.004 (0.02)	2.8	-0.003 (0.02)	3.3	0.000 (0.00)	0.5	-0.001 (0.01)	1.0
Maternal Weight	-0.008 (0.01)	5.9	0.004 (0.00)	-4.4	0.012 (0.01)	12.4	-0.003 (0.00)	2.8
Smoking during Pregnancy	0.003 (0.01)	-2.3	0.004 (0.01)	-3.9	0.005 (0.01)	5.4	-0.003 (0.01)	2.7
Breastfeeding	-0.011 (0.02)	8.3	0.001 (0.00)	-1.1	0.005 (0.01)	5.3	-0.004 (0.01)	3.7
Solids	-0.002 (0.00)	1.8	0.000 (0.00)	0.0	0.026 (0.01)[†]	27.9	-0.007 (0.01)	5.7
Television Viewing	0.005 (0.02)	-3.5	0.003 (0.01)	-3.5	0.000 (0.00)	0.3	0.003 (0.01)	-2.2
Physical activity	0.007 (0.01)	-4.9	0.001 (0.00)	-1.6	0.013 (0.01)	13.5	-0.002 (0.00)	2.0
Sugar Sweetened Beverages	-0.020 (0.02)	15.2	-0.016 (0.01)	17.3	0.007 (0.01)	7.3	-0.016 (0.01)	13.8
Childcare	0.002 (0.00)	-1.4	0.004 (0.01)	-4.6	-0.003 (0.00)	-3.0	0.002 (0.00)	-1.4
Fruits and Vegetables	0.000 (0.00)	-0.1	0.000 (0.00)	0.2	0.000 (0.00)	-0.4	0.000 (0.00)	-0.2
Infant weight gain	-0.051 (0.02)*	37.9	-0.026 (0.02)	27.9	0.009 (0.01)	10.1	-0.007 (0.02)	6.3
Family meal	-0.011 (0.01)	8.3	-0.007 (0.01)	7.6	-0.002 (0.00)	-2.5	0.001 (0.00)	-1.1
Total	-0.134 (0.05)*		-0.092 (0.05)[†]		0.094 (0.03)*		-0.116 (0.04)*	

[±]Percent Explained (PE%)
[†] $p<0.10$
*$p<0.05$

Table 2.3: Oaxaca-Blinder decomposition of BMI Z-Scores difference, Females

	White vs. African-American		White vs. Hispanic		White vs. Asian		White vs. American-Indian	
	Explained		Explained		Explained		Explained	
	β (SE)	%	β (SE)	%	β (SE)	%	β (SE)	%
Overall PE (%)±		94.5		53.8		14.9		45.2
Age	-0.005 (0.01)	2.7	0.001 (0.00)	-0.8	0.001 (0.00)	1.9	-0.014 (0.01)	10.4
Socio-economic Status	-0.055 (0.03)	32.1	-0.061 (0.04)	63.3	0.027 (0.02)	59.7	-0.052 (0.03)	37.8
Food Insecurity	-0.019 (0.01)	11.0	-0.012 (0.01)	12.1	0.003 (0.00)	6.6	-0.019 (0.01)	13.6
Neighborhood safety	-0.019 (0.02)	10.8	-0.010 (0.01)	10.2	0.000 (0.00)	-1.0	-0.015 (0.01)	10.5
Maternal Weight	-0.008 (0.01)	4.7	0.001 (0.00)	-1.0	0.015 (0.01)	32.8	-0.006 (0.01)	4.1
Smoking during Pregnancy	-0.002 (0.01)	1.0	-0.003 (0.01)	3.3	-0.004 (0.01)	-9.4	0.002 (0.01)	-1.1
Breastfeeding	-0.024 (0.02)	14.0	0.005 (0.00)	-5.5	0.009 (0.01)	19.5	-0.005 (0.01)	3.5
Solids	-0.003 (0.01)	2.0	0.001 (0.00)	-0.6	0.005 (0.01)	11.7	-0.002 (0.00)	1.2
Television Viewing	0.001 (0.02)	-0.4	0.000 (0.01)	-0.5	0.000 (0.00)	-0.2	0.000 (0.01)	-0.2
Physical activity	0.002 (0.00)	-1.0	0.002 (0.00)	-1.7	0.005 (0.01)	11.5	0.000 (0.00)	-0.2
Sugar Sweetened Beverages	0.002 (0.01)	-1.2	0.002 (0.01)	-1.5	-0.001 (0.01)	-2.5	0.002 (0.01)	-1.4
Childcare	-0.008 (0.01)	4.4	0.017 (0.01)	-17.3	-0.009 (0.01)	-19.2	0.007 (0.01)	-4.9
Fruits and Vegetables	0.000 (0.00)	-0.2	0.000 (0.00)	0.0	0.000 (0.00)	-0.4	0.000 (0.00)	0.0
Infant weight gain	-0.045 (0.02)*	26.3	-0.046 (0.02)*	47.0	-0.006 (0.01)	-13.7	-0.040 (0.02)*	29.2
Family meal	0.011 (0.01)	-6.1	0.007 (0.01)	-6.9	0.001 (0.00)	2.5	0.003 (0.00)	-2.5
Total	-0.173 (0.05)*		-0.097 (0.05)*		0.045 (0.03)		-0.138 (0.04)*	

±Percent Explained (PE%)
† p<0.10
*p<0.05

Discussion

Our study aimed to better characterize factors underlying racial/ethnic disparities in early childhood obesity. We found that it was largely socio-economic measures that accounted for a substantial part of the explained disparities in BMI z-scores between racial/ethnic minority children and their white peers. Indeed, SES and SES indicators (food insecurity, living in unsafe neighborhoods) collectively accounted for ~55% to 86% of explained racial differences among girls. Beyond SES, the rate of infant weight gain in the first 9-months also emerged as a key contributory factor underlying racial/ethnic disparities in early childhood obesity. Rapid infant weight gain has been previously found to be associated with childhood obesity.[30-32] If this association is causal, then interventions that target determinants of rapid infant weight gain could lead to reductions in observed racial/ethnic disparities in childhood obesity. Breastfeeding duration, formula feeding, feeding to schedule, maternal pre-pregnancy BMI and gestational weight gain are some modifiable exposures that have been linked to rapid infant weight gain,[33-37] and can be effective policy or intervention targets. Interventions like in-hospital and in-home lactation support for new mothers, and improved parental paid leave policies are some strategies that could be implemented to enhance rates and duration of breastfeeding. Interventions could also target additional risk factors that contributed to explained gaps, including sugar sweetened beverage consumption and early introduction of solids.

An unexpected finding in this study was that some obesity risk factors (e.g. fruit and vegetable consumption and TV viewing) played little or no role in explaining race/ethnic differences in children's BMI z-scores. The negligible effect on observed racial/ethnic disparities could be because the risk factors examined were not significant predictors of BMI z-scores at kindergarten entry in our study sample, or the prevalence of these risk factors did not vary significantly across racial groups.

We also found that obesity risk factor profiles were largely more favorable among Asian children, compared to their racial/ethnic peers. They also had consistently lower BMI z-scores than white children. A larger proportion of Asian parents had adopted practices that appeared to be beneficial to their children's weight status, e.g., breastfeeding, and lower rates of maternal smoking during pregnancy. Although this favorable risk factor profile could have been due in part to their higher socioeconomic status, it is notable that the prevalence of obesity risk factors among Asian children was lower in many cases than among their equally advantaged white peers. This could indicate that beyond socio-economic advantage, Asian families could also be benefiting from the influence of other factors such as cultural practices, traditional values or other behaviors that protect them from adopting unhealthful practices that lead to childhood obesity.

Previous studies that evaluated the role of obesity risk factors found that maternal, infant and early life risk factors fully explained racial/ethnic differences in preschool children's weight status. Weden et al[14] found no black/white differences in US preschool children's weight status, after adjusting for prenatal, perinatal and early life risk and protective factors. Another study of a prospective pre-birth cohort of children in eastern Massachusetts found that racial/ethnic differences in children's BMI z-scores at age 7 years became small and non-significant after adjusting for various obesity-related life risk factors.[16] In contrast, using decomposition techniques in this study - we found that with all the covariates included in the model, there remained significant unexplained racial/ethnic differences in BMI Z-scores for some groups. We also noted that covariates that explained disparities differed by race/ethnicity and gender. For example, the same covariates that explained ~95% of the observed disparities in BMI z-scores between white and African-American girls only explained 45% of the disparities between white and American-Indian girls. The remaining unexplained disparities seen in some racial/ethnic groups could be attributed to additional unmeasured factors that were unaccounted for in this study. Household level factors, (e.g. dietary quality, acculturation, or family-specific practices), as well as broader, structural factors (e.g. national food policies and local housing laws) could be additional forces underlying racial/ethnic disparities in children's weight status. This underscores the need for tailored policies and programs that target unique factors at play in each group.

This study had several limitations. Causal effects of the risk factors on obesity were not estimated in this study. The decomposition analysis was used to describe relationships that characterize obesity disparities. Even though we accounted for a wide array of confounders and obesity risk factors, there is still potential for residual confounding or misspecification of some of the variables in the model. Results of studies assessing racial/ethnic disparities could vary depending on how SES is measured. For this reason, it has been recommended that researchers conducting such analyses should assess the robustness of their findings by using multiple appropriate SES measures.[38] We used a composite variable for our SES measure that comprised information on the mother and father's educational attainment, occupational category and prestige score, and household income. In spite of these limitations, we believe our findings make an important contribution to the field by highlighting the extent to which obesity risk factors explain racial/ethnic disparities.

Conclusion

This study provides a nuanced picture of the role obesity risk factors play in explaining racial/ethnic disparities in preschool children's weight status. Racial/ethnic disparities are to a large extent explained by differences in family socioeconomic status, followed by rapid infant weight gain, sugar sweetened beverage consumption and lack of breastfeeding. Interventions implemented early in the life-course that target these key contributory risk factors could potentially help reduce the magnitude of racial/ethnic disparities in early childhood obesity.

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CHAPTER 3: Is Childcare Attendance Associated with Increased Risk of Obesity? Revisiting the Evidence

Abstract

Background: Several observational studies have reported that children who receive non-parental childcare are at increased risk of obesity. However, this may be due to unmeasured confounding or selection into different types of childcare arrangement. It is not well established whether this association reflects a causal effect of childcare attendance on obesity risk.

Objective: We examined the effect of attending childcare on children's BMI z-scores, using nationally representative data of ~10,700 children in the Early Childhood Longitudinal Study Birth Cohort followed from age 9 months through kindergarten entry.

Methods: We first employed OLS regression to evaluate longitudinal associations between childcare attendance at 24months and BMI z-scores at kindergarten entry, controlling for background child, family and neighborhood characteristics. Because type of childcare is associated with unobserved confounding factors, we repeated the analysis using two quasi-experimental approaches: 1) individual fixed effect models, which control for all observed and unobserved time-invariant confounders; and 2) instrumental variable (IV) analysis.

Results: At 24 months, 48.7% of children were in non-parental childcare, and 35.1% of children were overweight or obese at kindergarten entry. In linear regression models, compared to children in parental care, children in non-parental childcare at 24 months had higher BMI z-scores at kindergarten entry (0.08 (SE 0.03) $p=0.01$). By contrast, fixed effects and IV models revealed no significant effect of childcare on BMI z-score (fixed effects model: $\beta=0.02$ (SE 0.02) $p=0.62$); (IV model: $\beta=1.12$ (SE 0.76) $p=0.14$).

Conclusions: Our findings suggest that the link between non-parental childcare and obesity may not be causal. Previously reported associations may be confounded by unobserved family circumstances resulting in selection into different types of childcare arrangement.

Introduction

Childhood obesity remains a significant public health challenge in the United States, with about 32% of 2-19 year olds being classified as overweight or obese in 2011-2012.[1] Rates have remained unchanged since 2009-2010.[2] Various modifiable factors, e.g. maternal smoking during pregnancy, early life programming, diet, physical activity, hours of television viewing, have been associated with increased risk of early childhood obesity.[3-16] Public health efforts have been directed towards childhood obesity prevention, with a recent emphasis on the early childhood period.

In 2011, approximately 60% of US children < 5 years were in some kind of regular childcare.[17] Given the significant amount of time that preschool aged children spend in non-parental childcare, researchers have hypothesized that childcare attendance may be another contributor to childhood obesity. Several studies have evaluated if there is a causal relationship between childcare attendance and children's weight status.[18-23] Most of these studies reported an increased risk of obesity among children in non-parental childcare, compared to those cared for by their parents.[18-23] However, a major challenge is the fact that children in non-parental childcare and those in parental care may differ across many unmeasured variables not accounted for in existing studies. If the decision to place a child in non-parental childcare is correlated with unmeasured characteristics that also affect the child's weight status (e.g. degree of parental concern, vigilance over the child's health, or dietary choices), conventional multivariable modeling approaches may yield biased estimates.

Given recent increased focus on childcare programs as a critical component of obesity prevention efforts, a better understanding of the impact of childcare on obesity is essential. Ideally, a randomized controlled trial would help resolve this research question, but true experiments are expensive, time consuming, and difficult to launch. In the absence of experimental evidence, quasi-experimental analytical approaches can be useful to shed light on the extent to which childcare attendance may be causally linked to obesity. The goal of this study was to examine the effect of attending childcare on children's BMI z-scores, using both conventional methods as well as quasi-experimental techniques to account for selection bias and unmeasured confounding. Using data from a unique birth cohort study of ~10,700 children in the US followed from age 9-months through kindergarten entry, we compare findings from conventional multivariable OLS modeling approaches to findings based on two quasi-experimental approaches designed to minimize the effect of selection bias and unmeasured confounding, viz. fixed effects analysis and instrumental variable (IV) estimation. To our knowledge, this is the first study to use quasi-experimental techniques to examine the links between childcare attendance and children's weight status, a question with important policy implications for childhood obesity prevention.

Methods

We used data from the Early Childhood Longitudinal Study Birth Cohort (ECLS-B), a study conducted by the National Center for Education and Statistics (NCES).[24] ECLS-B includes a nationally representative sample of about 10,700 US children from diverse socio-economic and racial/ethnic backgrounds, born in 2001 and followed over ~6 years. Children's physical, social, and emotional development characteristics were measured in multiple settings. Data were also collected from parents/guardians, teachers, childcare and early education providers. Five waves of data were collected: Wave 1 (9 months, 2001-02) Wave 2 (2 years, 2003-04), Wave 3 (preschool, 2005-06), Wave 4 (kindergarten, 2006-07) and Wave 5 (a sample of children who entered kindergarten in 2007-2008). Twins, low birth-weight, American-Indian and Alaska Native, Chinese, other Asian and Pacific-Islander children were oversampled. Data from waves 1-4 were used for this study.

Outcome variable

The outcome variable for this study was children's BMI-z score at each wave. Children's length or height and weight were measured at each wave of ECLS-B data collection. A measure mat, stadiometer, and a digital bathroom scale were used to obtain children's length, height, and weight measurements, respectively. For all children ≥24months, we used the Centers for Disease Control and Prevention (CDC) sex-specific growth charts to calculate BMI percentile ranking and z-scores.[25] For longitudinal analyses, we used repeated continuous measures of the BMI z-scores.

Exposure variable

Childcare Arrangement: Parents were asked questions about different types of childcare (other than occasional babysitting) the child received on a regular basis, regardless of whether there was a charge or fee. Using parent responses, ECLS-B developed a composite variable that indicated the childcare arrangement for each child, based on where the child spent the most hours per week. We dichotomized this variable as parental care (reference category) vs. non-parental childcare.

Other covariates: Additional model covariates and confounders were the child's age, gender, race/ethnicity; maternal age and weight, family socio-economic status (SES), household structure (two-parent vs. single-parent)), and neighborhood-level (neighborhood safety) characteristics. The SES variable was an ECLS-B derived composite variable that was categorized into quintiles. It comprised information on the mother and father's educational attainment, occupational status, and household income. We used the ECLS-B SES composite variable from wave 1 (baseline) of data collection. Neighborhood safety was based on a question to assess parent's perception of their neighborhood safety: *"Do you consider your neighborhood very safe from crime, fairly safe, fairly unsafe, or very unsafe."* Possible responses included very safe, fairly safe, very unsafe and fairly unsafe. If parents' response was very unsafe and fairly unsafe, the child's neighborhood safety was categorized as unsafe (vs. safe).

Statistical Analysis

We examined weight and height trajectories over time, excluding children with implausible values (n=100), who were born with low or very low birth-weight (birth-weight <2500 g) (n=3000), had height and weight values missing for waves (n=150) or extreme BMI values (z-score >3 SD or ≤-3SD) (n=400), with a final overall sample size of ~7200. Descriptive analyses accounted for the ECLS-B complex sample design and response rates, using appropriate ECLS-B weights. We then employed standard multivariable OLS regression to evaluate longitudinal associations between childcare attendance at 24months and BMI z-scores at kindergarten entry, adjusting for additional covariates. To further examine the role of selection and unmeasured confounding, we used two quasi-experimental techniques to improve causal inference using non-experimental data, namely individual fixed effect and instrumental variable (IV) models. I*ndividual fixed effect* models, used to analyze longitudinal data with repeated measures, attempts to adjust for both observed and unobserved time-invariant confounders.[26] In this within-subject design, each individual is used as his or her own control, and average differences are used to estimate the treatment effect.[26] This approach was feasible in our study because changes in the type of childcare were fairly common among children in our sample, i.e., ~56% of children transitioned from parental to childcare (or vice versa) at some point during the follow-up. We estimated the "childcare effect" for each child by comparing each child's BMI z-score in parental care vs. non-parental childcare, and then averaged differences across the population, to obtain the average treatment effect. The fixed effects models also included the following time-varying covariates: employment status, household structure, change in place of residence, and socio-economic status for each wave. To isolate effects of unidirectional transitions from parental care to non-parental childcare, we carried out supplementary analyses on a subset of children who had only moved from parental care to non-parental childcare across waves. Last, to evaluate a potential delayed effect of childcare on future BMI z-scores, we also estimated models that examined the lagged effects of childcare transitions on BMI z-scores.

Instrumental variable (IV) analysis - a known econometric technique, examined whether 'semi-random' variation in childcare attendance caused by a third variable believed to be unrelated to BMI might lead to increased BMI z-scores. We used two-stage least squares (2SLS) regression to estimate effects. Three assumptions must be met for IV analysis to yield unbiased estimates. The instrument must: 1) affect the exposure; 2) be unrelated to the outcome, except through its effect on the exposure; and 3) be independent of the unmeasured confounding.[27] The main challenge in IV analysis is to identify an instrument that meets all three conditions. After exploring several potential alternatives, we chose as instrument - the number of relatives that live close to the family, assessed by the question: "How many of your relatives live in the area?" Our rationale was that the number of relatives living in the area would make the need for non-parental childcare more or less, but it would not necessarily be directly associated with BMI other than through influencing the risk of childcare attendance. To minimize the impact of confounding variables that could invalidate the third criterion, we adjusted for a wide array of additional covariates, conditional on which we expected the instrument to be valid. We evaluated the strength of the instruments (criterion 1 above) using conventional F-statistics from the first stage in the 2SLS approach. The F statistic was 19.6, indicating the absence of a weak instrument problem.[28] All analyses were performed using statistical software (SAS v9.3; SAS Institute, Inc, Cary, NC). The study was approved by NCES and Harvard School of Public Health IRB. Per ECLS-B data reporting requirements, all figures are rounded to the nearest 50.

Results

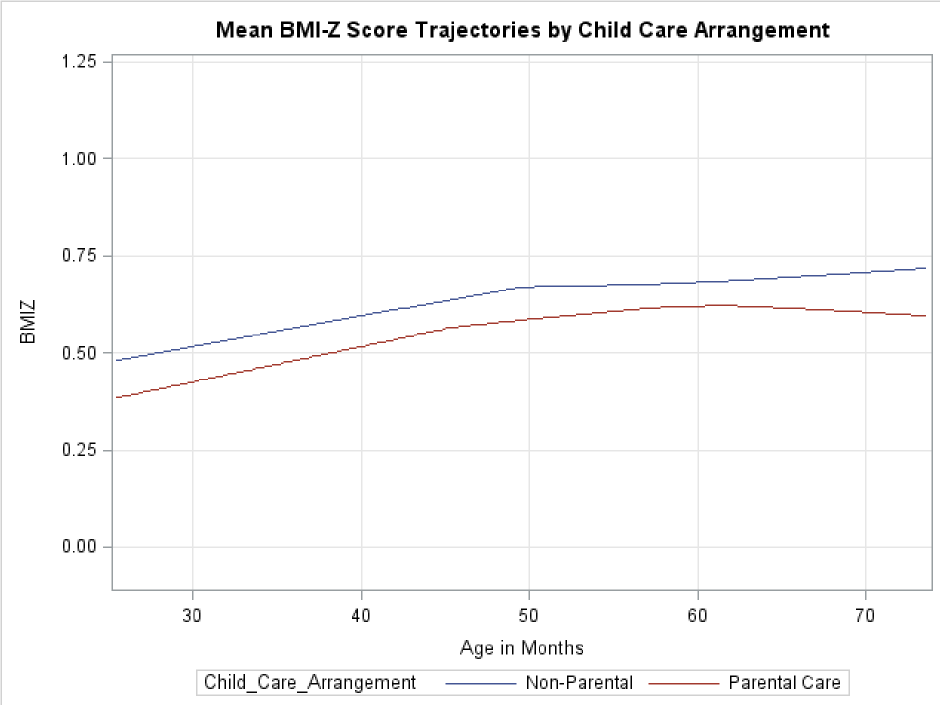
Table 3.1 shows socio-demographic characteristics of the sample, by childcare status. Overall, about half of the children were white (54.6%), males (51.7%) and had parents with ≤ High School/GED education

(46%). At 24 months, 48.7% of children were in non-parental childcare and 35.1% of children were overweight/obese at kindergarten entry. African-American children comprised 11.1% of children in parental care, and 20.6% of children in non-parental childcare. A greater proportion of Hispanic children was in parental childcare – they comprised 26.6% of children in parental care, and 19.4% of children in non-parental childcare. Children with mothers with ≤High-School diploma/GED comprised 52.1% of children in parental care and 39.7% of children in non-parental childcare. The average BMI z-score of children in non-parental childcare was significantly higher than those in parental care at each wave of data collection ($p < 0.05$). (Figure 3.1)

Table3.1: Socio-demographic characteristics of sample population, overall and by childcare arrangement status

Characteristic	Overall (n~7200)	Parental care (%)	Non-Parental care (%)
Prevalence		51.3	48.7
Male	51.7	49.6	53.1
Child race			
African-American	15.7	11.1	20.6
Hispanic	23.1	26.6	19.4
Asian	3.4	3.7	3.1
Other	3.2	3.1	3.1
White	54.6	55.4	53.9
Household Income			
≤$25,000	33.9	37.0	30.3
$25,001-50,000	29.3	31.9	27.4
>$50,000	36.8	31.1	42.3
Parent Education			
≤High School/GED	46.0	52.1	39.7
Vocational school/Some College	29.3	27.3	31
≥Some College	24.8	20.6	29.3
Two parent household	80.6	85.6	75.3
Neighborhood is not safe	8.1	9.4	7.2
Overweight/Obesity Prevalence (%)			
2-yr (2003-04)	17.1	14.9	19.4
Preschool (2005–06)	34.4	33.1	35.7
Kindergarten (2006)	35.1	33.2	37.1

Figure 3.1: Mean BMI Z-Score Trajectories by Childcare Arrangement Status



Results from multivariable linear regression models are summarized in Table 3.2, alongside results from fixed effect and IV models. In regular OLS models, children in non-parental childcare at 24 months had higher BMI z-scores at kindergarten entry than children in parental care (β=0.08 (SE 0.03) p=0.01; n=4700). This represents about 12% of the mean BMI z-score. However, results from fixed effects regression models (column 2), which controlled for time-varying and time-invariant confounding, indicated no significant relationship between non-parental childcare and BMI z-score (β=0.02 (SE 0.02) p=0.41; n=4700). Sensitivity analyses to assess the impact of unidirectional changes in childcare arrangements across waves, as well as the lagged childcare variable yielded very similar results (model using subset of children: β=0.05 (SE 0.06) p=0.39; n=2400); (model using lagged childcare variable: β=0.01 (SE 0.02) p=0.66; n=4700).

Results from the first stage of the IV estimation are shown in the third column of Table 3.2 and suggest that our main instrument, the number of family members living in the area significantly increased the likelihood that children received non-parental childcare (β=0.04 (SE 0.01), F-statistic =19.6). (The type of non-parental childcare received was relative care.) Although estimates were imprecise and had large standard errors, results from the second stage of the IV (column 4) suggest that receiving non-parental childcare was not significantly associated with BMI z-score at kindergarten entry (β=1.12 (SE 0.76) p=0.14; n=4700). Because children in non-parental childcare comprised 3 different childcare categories (relative care, non-relative care, and center-based childcare), we conducted sensitivity IV analyses using pairwise comparisons between parental childcare and each type of non-parental childcare. None of these models yielded significant results.

Table 3.2: OLS, Fixed Effects and Instrumental Variable multivariable models examining the association of childcare attendance and BMI Z-scores*

	OLS multivariable regression analysis**	Fixed effects model analysis**§	First Stage Instrumental Variable	Instrumental variable analysis**
	β (SE)	β (SE)	β (SE)	β (SE)
Childcare	0.08 (0.03)*	0.02 (0.02)		1.12 (0.76)
Close Relative (1st stage IV analysis)†			0.04 (0.01)	
Age	0.01 (0.01)	0.003 (0.003)	0.02 (0.01)	-0.01 (0.02)
Sex	0.07 (0.03)*	0.09 (0.03)	0.01 (0.01)	0.05 (0.03)
Socioeconomic status	-.06 (0.01)	-0.07 (0.02)*	0.06 (0.01)	-0.13 (0.05)*
Race				
African-American	0.12 (0.05)*	0.05 (0.05)	0.14 (0.03)	-0.02 (0.12)
Hispanic	0.19 (0.04)*	0.12(0.04)*	0.03 (0.02)	0.16 (0.05)*
Asian	-0.18 (0.05)*	-0.15 (0.04)*	-0.02 (0.02)	-0.15 (0.06)*
Other	0.19 (0.05)*	0.14 (0.05)*	0.03 (0.02)	0.16 (0.06)*
Maternal age	0.00 (0.003)	0.000 (0.003)	-0.001	0.001 (0.003)
Neighborhood safety	0.04 (0.06)	-0.02 (0.05)	-0.06 (0.03)*	0.10 (0.08)
Household structure	-0.04 (0.04)	-0.01 (0.05)	-0.17 (0.02)*	0.13 (0.14)
Maternal weight	0.002 (0.00)*	0.002 (0.00)	0.00 (0.00)	0.002 (0.001)*

** Additional covariates in all models included child age, race/ethnicity, gender, maternal age, maternal weight, household structure, family socioeconomic status and neighborhood safety.
§Model also controlled for other time varying covariates – employment status, change in residence, household structure and socio-economic status for each wave of data
*p-value <.05
† Close relative variable only included in Instrumental Variable Analysis

Discussion

Non-parental childcare in early childhood has been associated with obesity. [18-23] In particular, children in relative, friend or home-based non-parental childcare have been previously reported to gain more weight, compared to children in parental care.[20,29] Our study, using two quasi-experimental approaches that attempt to minimize bias inherent in observational studies, does not provide strong evidence for a causal relationship between non-parental childcare and obesity.

Conventional analytical approaches, while often controlling for a rich set of measured confounders, may not fully account for unmeasured or unobservable differences between children in different childcare arrangements. For example, parents who choose to take care of their children at home may also be more likely to cook healthier diets or emphasize healthy habits than parents that send their children to child care. This would imply that it is not childcare per se which increases the risk of obesity but other unmeasured behaviors that tend to cluster among parents who stay home with their children, and which are correlated with child weight.

It is noteworthy, that not all studies evaluating the association between childcare and children's weight status have yielded a positive association. Some studies reported no significant association,[30-33] while one study found an inverse association among children with limited center-based childcare attendance in preschool years.[30] Inconsistencies in results may be due to differences in sample characteristics, analytical approach, or confounders controlled for in the studies. Some studies have also reported effect modification in the relationship by some familial characteristics. A UK based study found that the positive childcare/obesity relationship was limited to children of parents who had more socioeconomically advantaged backgrounds.[21]

Despite many strengths in our data and approach, several limitations in this study should be considered. Children in our sample were only followed through kindergarten entry; if the impact of childcare on weight status only manifests after this age, we would not have detected any effects using our data. However, a study that assessed the long term impact of childcare on weight status in female adults did not find any significant associations.[33] Fixed effects models control for time-invariant confounders but not time-varying confounders, some of which may be correlated with changes in BMI. We tried to minimize this bias by including as many time-varying confounders as possible in the model, but could still have omitted some important variables. Additional limitations of fixed effects analysis include the possibility that lag times were mis-specified, potential simultaneity, and sample size limitations because data on kids whose childcare arrangements did not change were not used. Finally, the IV technique could be biased when there are sample size limitations.[34] As such, results from the IV analysis should be interpreted with caution, given the large standard errors and the possibility that our analysis may have been under-powered. The IV analysis relies on strong assumptions that cannot be fully verified empirically. We repeated these analyses using three strong instruments, and results remained consistent. Overall, although quasi-experimental techniques are not without limitations, our results do provide a richer picture that casts doubt on the hypothesis that non-parental childcare is associated with higher risk of obesity.

Conclusion

Our results question findings from earlier studies and suggest that the association between childcare attendance and obesity may not be causal. Earlier reported associations may be confounded by unobserved family circumstances resulting in selection into different types of childcare arrangement. Results of previous studies have led to calls to revamp childcare policies and promote reorganization of childcare settings in order to address obesity risk factors among children in non-parental childcare. Because an increasing proportion of US children spend a significant amount of time in non-parental care, efforts to enhance the quality of care provided in these settings are reasonable approaches.

However, there is a need for a better understanding of factors that inform parents' childcare decisions in order to fully tease apart the association between childcare attendance and children's weight in the short or long term. Future studies, particularly rigorous randomized controlled trials may be required to fully address this complex question. Findings from such studies could inform how best to allocate limited obesity prevention resources.

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APPENDIX

Table 1.4: Sample Characteristics, Weighted Means and Frequencies, by Race/Ethnicity and Gender

	African-American	***Hispanic***	***Asian***	***American-Indian***	***Pacific-Islander***	***White***
MALES						
Birth-weight in grams (SE)‡	3351.5	3467.2	3318.1 (25.1)	3533.0	3531.7	3519.4
Weight-for Length Z-score (at 9 months)	0.49	0.46	0.16 (0.10)	0.95	0.67	0.50
BMI Z-score (SE)						
2-yr (2003-04)	0.58	0.66	0.28 (0.12)	0.73	0.14	0.44
Preschool (2005–06)	0.65	0.86	0.44 (0.10)	1.04	0.49	0.59
Kindergarten (2006)	0.75	0.93	0.48 (0.11)	0.93	0.60	0.58
Overweight/Obesity Prevalence (%)						
2-yr (2003-04)	17.3	20.1	12.2	27.3	5.1	16.3
Preschool (2005–06)	37.2	39.9	24.5	47.0	39.7	29.7
Kindergarten (2006)	41.0	43.7	29.4	42.8	37.0	29.0
FEMALES						
Birth-weight in rams (SE)‡	3282.7	3331.9	3280.6 (19.5)	3345.1	3252.8	3417.8
Weight-for Length Z-score (at 9 months)	0.45	0.54	0.01 (0.12)	0.96	0.58	0.34
BMI Z-score (SE)						
2-yr (2003-04)	0.30	0.43	0.30 (0.11)	0.62	0.25	0.30
Preschool (2005–06)	0.70	0.79	0.38 (0.09)	1.00	0.95	0.60
Kindergarten (2006)	0.76	0.78	0.34 (0.10)	1.04	1.19	0.61
Overweight/Obesity Prevalence (%)						
2-yr (2003-04)	16.4	17.0	14.0	22.2	13.3	16.5
Preschool (2005–06)	36.8	42.6	28.7	47.1	55.7	30.9
Kindergarten (2006)	39.9	39.9	29.6	49.2	64.0	31.5

Table 1.5: OLS Model for associations between birth-weight and weight-for-length z-score and race/ethnicity, by gender

	Male		Female	
	Birth-weight(g)	*Weight-for-Length Z-score*	*Birth-weight(g)*	*Weight-for-Length Z-score*
Intercept	3427.1 (12.0)	0.48 (0.07)	3291.0 (11.7)	0.35 (.07)
Race/Ethnicity†				
African-American	-127.5(11.8)*	.02 (.07)	-108.2 (11.5)*	0.01 (0.07)
Hispanic	-5.1(11.4)	0.07 (0.06)	-40.6 (11.1)*	0.21 (0.06)*
Asian	-170.9(11.0)*	-0.31 (0.06)*	-134.1 (11.0)*	-0.22 (0.06)*
American-Indian	55.9 (14.3)*	0.28 (0.08)*	42.4 (13.5)*	0.28 (0.08)*
Pacific-Islander	104.2 (30.2)*	0.40 (0.17)*	-3.4 (33.3)	0.35 (0.20)
Socio-Economic Status	15.8 (2.9)*	0.01(0.02)*	21.7 (2.9)*	-0.01 (0.02)

*p-value <.05

Table 1.6: Random effects growth models adjusted mean difference in BMI z-score and BMI z-score change by race/ethnicity and gender

	Male		Female	
	Model 1® β (SE)	***Model 2***¥ β (SE)	***Model 1***® β (SE)	***Model 2***¥ β (SE)
Intercept	-0.77 (.14)	-216 (0.16)	-0.85 (.14)	-2.13 (.16)
Race/Ethnicity†				
African-American	.10 (.08)	0.04 (.08)	-0.06 (.08)	-0.11 (.08)
Hispanic	0.20 (.08)*	0.17 (.08)*	0.10 (.08)	0.04 (.08)
Asian	-0.03 (.08)	-0.07 (.08)	-0.08 (.08)	-0.06 (.08)
American-Indian	0.38 (.09)*	0.36 (.09)*	0.24 (.09)*	0.19 (.09)*
Pacific-Islander	0.04 (.20)	0.11 (.20)	0.18 (.22)	0.10 (.23)
Age§	.004 (.001)*	.004 (.001)*	.007 (.001)*	.007 (.001)*
Socioeconomic status	-0.04 (0.01)*	-0.05 (.01)*	-0.07 (0.01)*	-0.06 (0.01)*
African-American*Age	.003 (.002)	.003 (.002)	.005 (.002)*	.004 (.002)*
Hispanic*Age	.001 (.002)	.000 (.002)	.000 (.002)	.000 (.002)
Asian*Age	-.004 (.002)	-.004 (.002)*	-.004 (.002)*	-.005 (.002)*
American-Indian*Age	.001 (.002)	.000 (.003)	.000 (.002)	.000 (.002)
Pacific-Islander*Age	.007 (.006)	.005 (.006)	.004 (.006)	.008 (.006)
Birth-weight	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*
Infant weight gain		1.96 (0.11)*		1.88 (0.11)*

®Adjusted for Birth-weight
¥Adjusted for Birth-weight and infant weight gain
†*Reference group =non-Hispanic white*
*p-value <.05
§Age is centered at 24-months

Table 2.4: Variables, Measurement and Waves of Data Collection

Variable	*Variable Questions and Wave of Measurement*	How Variable was Categorized
Maternal history of smoking during pregnancy	*"In the last 3 months of your pregnancy, how many cigarettes or packs did you smoke on an average day?" (Wave 1)*	Maternal smoking during pregnancy vs. not
History of Breast-feeding	*"Did you ever breast-feed (X)?" (Wave 1)*	Ever breastfed vs. not
Early introduction of solid foods	*"How old was (X) in months when solid food was first introduced? (Wave 1)*	Early introduction of solids (<4months) vs. not.
Infant weight gain	This was based on the 9-month rate of infant weight gain, calculated as the difference in weight at 9-months and birth-weight (in kg), divided by the age in months at the first wave of data collection (~9 months).	Continuous variable
Television Viewing	*"On average, about how many hours of television {does} {X} watch at home each weekday, that is, Monday through Friday?" PROBE: This does not include videos or DVDs.* *"On average, about how many hours of videos or DVDs {does} {X} watch at home each weekday, that is, Monday through Friday?" (Same questions repeated for weekends) (Wave 3)*	≥2 hours/day of TV on weekdays or weekends, vs. not.
Sugar Sweetened Beverage (SSB) Consumption	*"During the past 7 days, how many times did your child drink Soda pop (for example, Coke, Pepsi, or Mountain Dew), sports drinks (for example, Gatorade), or fruit drinks that are not 100% fruit juice (for example, Kool-Aid, Sunny Delight, Hi-C, Fruitopia, or Fruitworks)?" (Wave 3)*	*Possible responses: 1 time/day, 2 times/day, 3 times/day, 4 or more times/day, 1-3 times during the past 7 days, 4-6 times during the past 7 days, and child did not drink any during the past 7 days.* Regular SSB drinkers (children whose parents reported that they drank ≥1 serving of SSB/day) vs. infrequent/nondrinkers.
Number of Family meals/week	*"Now I'd like to ask you about family routines. In a typical week, please tell me the number of days… at least some of the family eats the evening meal together?" (Wave 3)*	*Possible responses ranged from 0-7 days.* Categorized children as having family meals if the family ate at least 4 meals together/week, vs. not.

Fruit and Vegetable Consumption	*"During the past 7 days, how many times did your child eat fresh fruit, such as apples, bananas, oranges, berries or other fruit such as applesauce, canned peaches, canned fruit cocktail, frozen berries, or dried fruit? Do not count fruit juice." Possible responses included: "1 time/day, 2 times/day, 3 times/day, 4 or more times/day, 1-3 times during the past 7 days, 4-6 times during the past 7 days, and child did not eat fruit during the past 7 days."* <u>AND</u> *"During the past 7 days, how many times did your child eat vegetables other than French fries and other fried potatoes? Include vegetables like those served as a stir fry, soup, or stew, in your response," (Similar response categories as above for fruit)*	Combined responses to both questions, and dichotomized variable as adequate fruit and vegetable consumption (1 time/day, 2 times/day, 3 times/day, 4 or more times/day) vs. inadequate fruit and vegetable (for responses: 1-3 times during the past 7 days, 4-6 times during the past 7 days, and child did not eat fruit/vegetables during the past 7 days) consumption.
Physical Activity	*In the past month, how often did you do the following things with {X}?* *Take {X} outside for a walk or to play in the yard, a park, or a playground?*	*Possible responses was: more than once a day, about once a day, a few times a week, a few times a month, rarely, or not at all?* We dichotomized this variables based on parent responses to how often the child went outside to walk or play, (at least once a day vs. <once/day).
Food Insecurity	*a. {I/we} worried whether {my/our} food would run out before {I/we} got money to buy more.* *b. The food that {I/we} bought just didn't last, and {I/we} didn't have money to get more.* *c. {I/We} couldn't afford to eat balanced meals.* *d. {I/We} relied on only a few kinds of low-cost food to feed {{CHILD}/the children}* *because {I was/we were} running out of money to buy food.* *e. {I/We} couldn't feed {{CHILD}/the children} a balanced meal because {I/we} couldn't afford that. (Wave 1)*	Possible responses included often, sometimes or never true. If parents had three or more affirmative responses to questions, the household was categorized as food-insecure (vs. food secure).
Neighborhood safety	*"Do you consider your neighborhood very safe from crime, fairly safe, fairly unsafe, or very unsafe" (wave 1)*	Possible responses included very safe, fairly safe, very unsafe and fairly unsafe. If parents' response was very unsafe and fairly unsafe, the child's neighborhood safety was categorized as unsafe (vs. safe).
Childcare Arrangement	*ECLS-B derived composite variable indicating the primary, non-parental child care arrangement, based on where the child spent the most hours per week. (Wave 3)*	Dichotomized as parental child-care vs. non-parental child-care.

Socio-economic status:	*Composite variable developed by ECLS-B for children's socio-economic status at baseline data collection (wave 1). Variable comprised information on the mother and father's educational attainment, occupational category and prestige score, and household income. (Wave 1)*	Categorized as quintiles – (variable generated by ECLS-B)